

COMMUNICATIONS

The Mobile Internet – The Next Big Thing

Electrons & Photons: You need both!

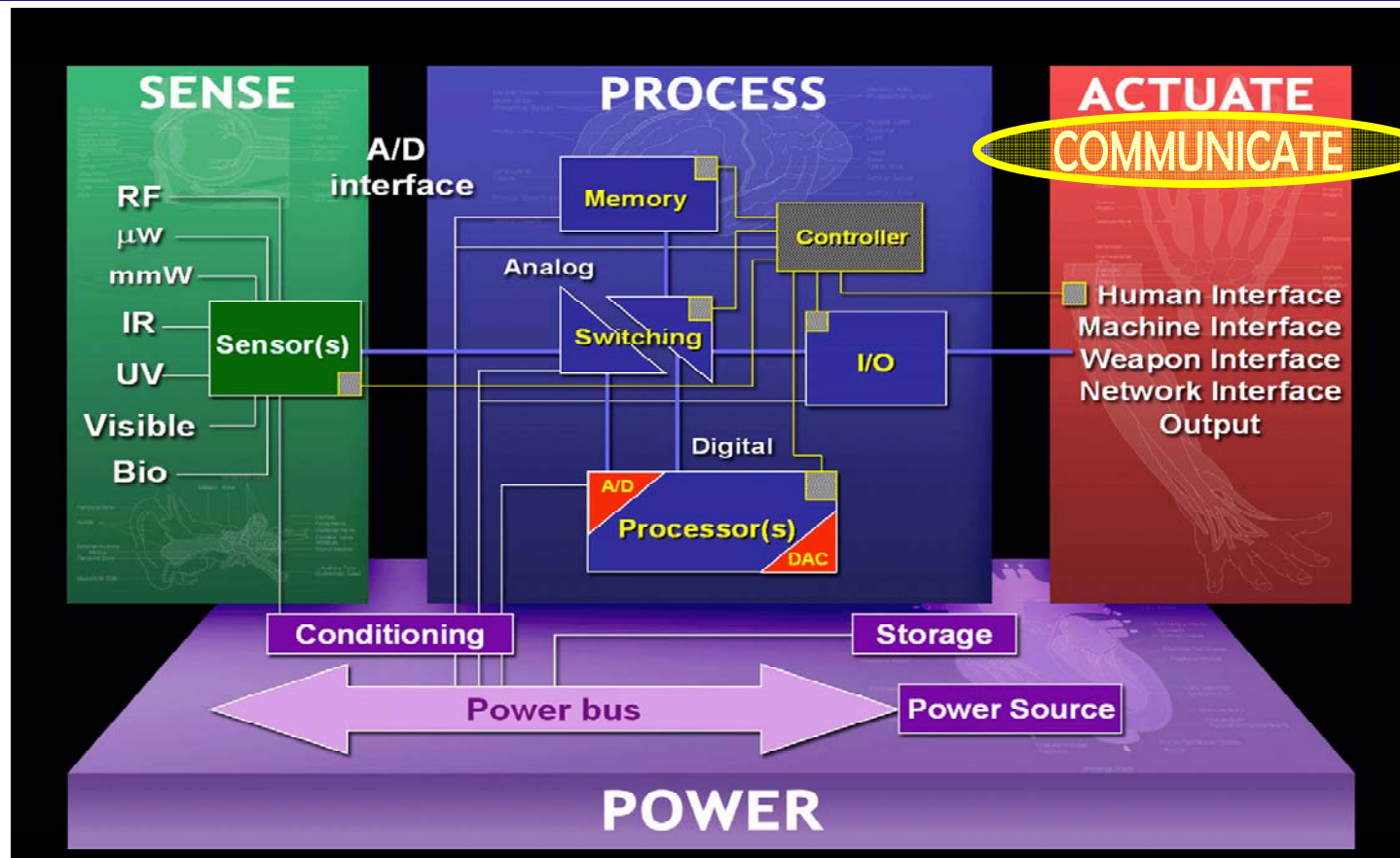


Dr. Steve Pappert
DARPA/MTO Symposium
March 5, 2007

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Integrated Microsystem



Communications: Voice, Video & Data Information Transfer

20th Century

Platform Centric Warfighting

Comms → Wired Interconnects & Data Links



21st Century

Network Centric Warfighting

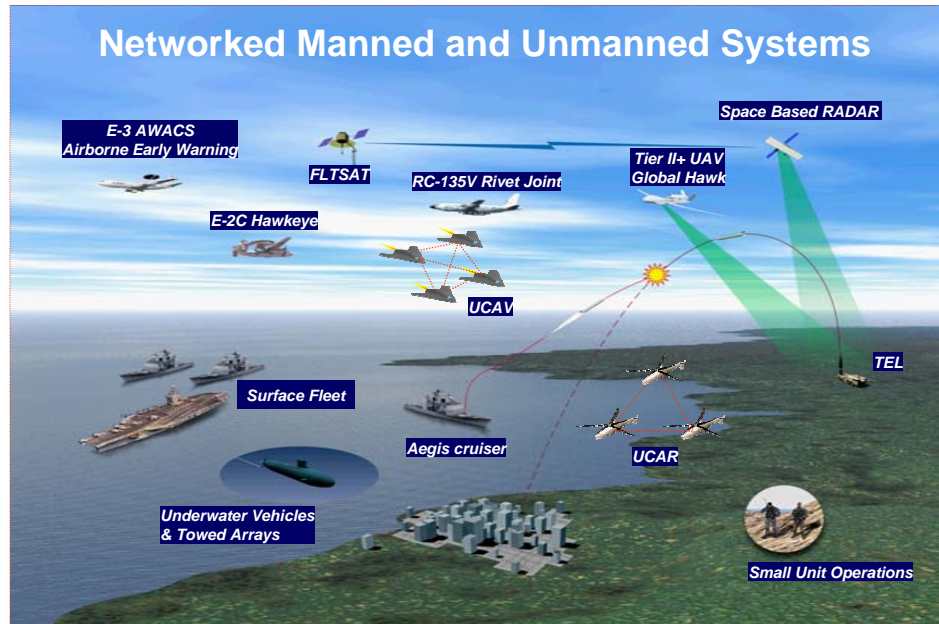
Comms → Wired & Wireless Links

The Military Comms Problem

Network Centric Operations



21st Century RF Technologies Will Change The Way We Engage Our Adversaries



**See Anything...
From Anywhere...
At Anytime...**

PERSISTANT, STANDOFF SURVEILLANCE

AND

Provide Real-Time Global Information Distribution

SENSOR TO SHOOTER INFORMATION GRID

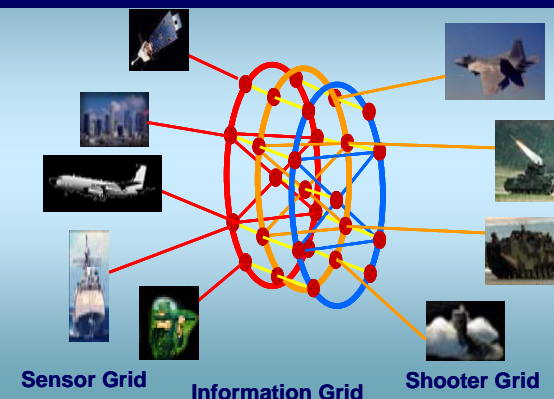
Expanding ISR Demands

The SIGINT logo, featuring the word "SIGINT" in white, bold, italicized capital letters on a blue oval background with a red border.The MASINT logo, featuring the word "MASINT" in white, bold, italicized capital letters, set against a blue oval background with a red border.

Multi-INT



Burgeoning Comms Demands

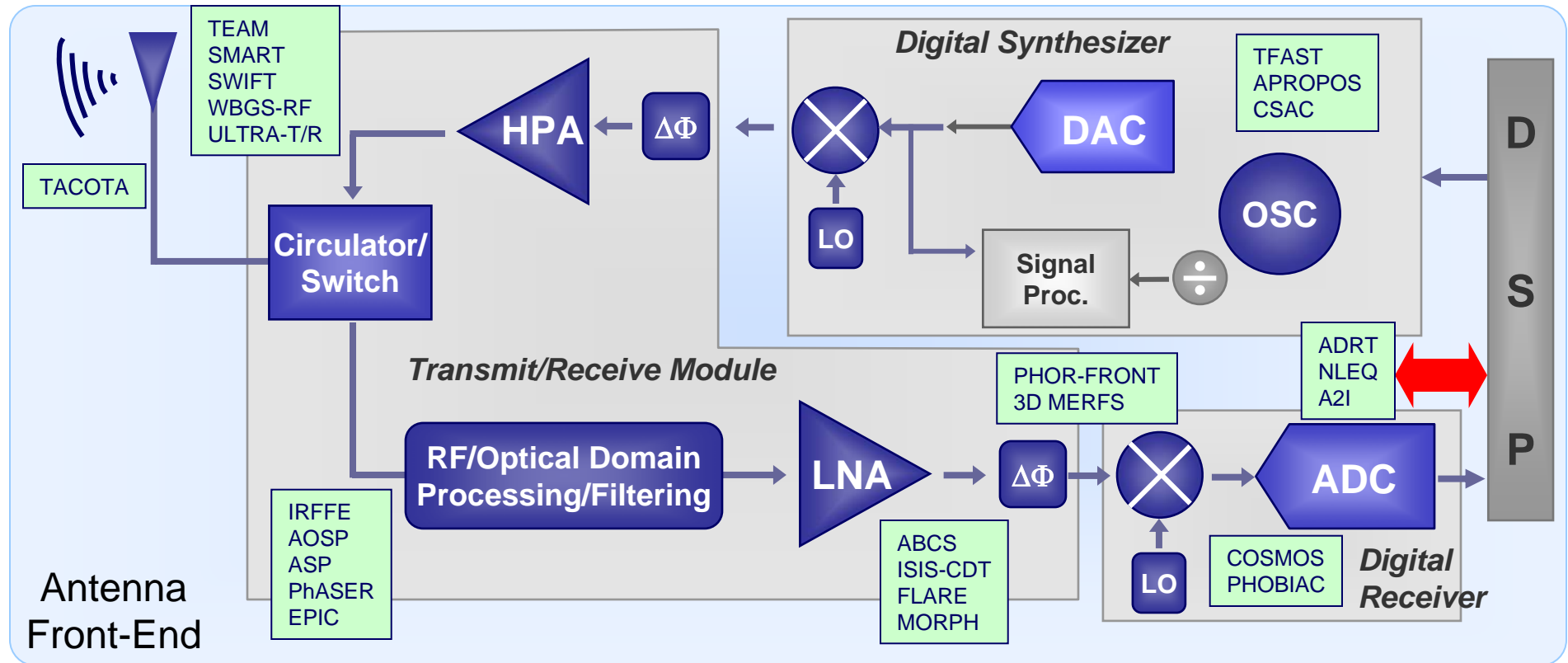




RF Front-End Technology Trajectory On Target To Satisfy The Military Comms Problem



DARPA's Current Programs ↔ Tomorrow RF Front-End Solutions



- >20 DARPA/MTO RF Programs across the spectrum
 - RF & Mixed Signal Electronics
 - Analog & Digital Photonics

Enables

Network Centric Warfare



5-10 yr.
timeframe



Ultimate Military Comms Solution

Driven by Capacity, Availability & Security

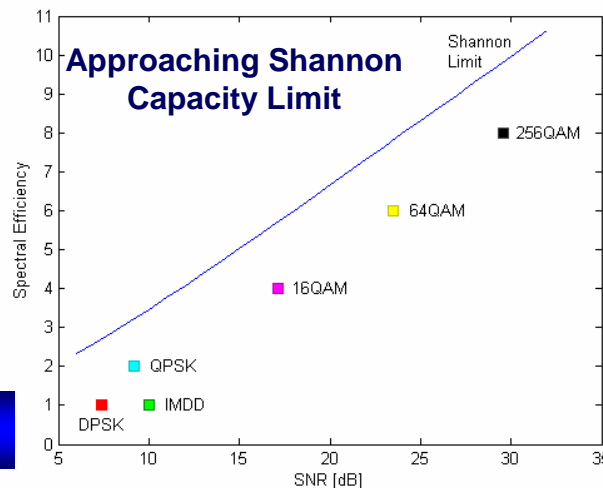


Spectrally efficient adaptive multi-level frequency hopping coherent waveforms

- **Multi-level complex waveforms** for high-capacity (short-up emitter)
- **Waveform agility** for SNR utilization
- **Multi-dimensional diversity** for link availability, LPI/LPD, anti-jam & security (e.g. frequency, polarization, spatial, ...)
- **Coherent detection** brings sensitivity and enables DSP channel compensation

Software Defined Agile Modems

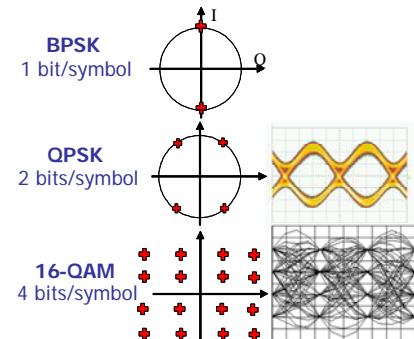
Link Capacity



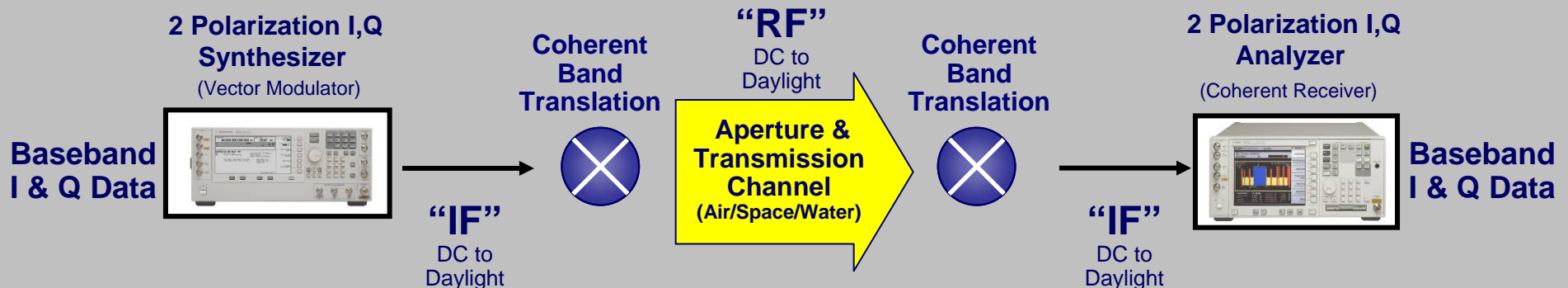
Waveform/Symbol Rate Agility

Modulation Agility

- Use modulation that is best suited for the target environment and link
- Enables variable bit rates and ultrahigh capacity per wavelength



Unified JTRS-Like RF to Optical Transmission Architecture



Overlaying Free-Space Optical Communications Brings Added Capacity & Security

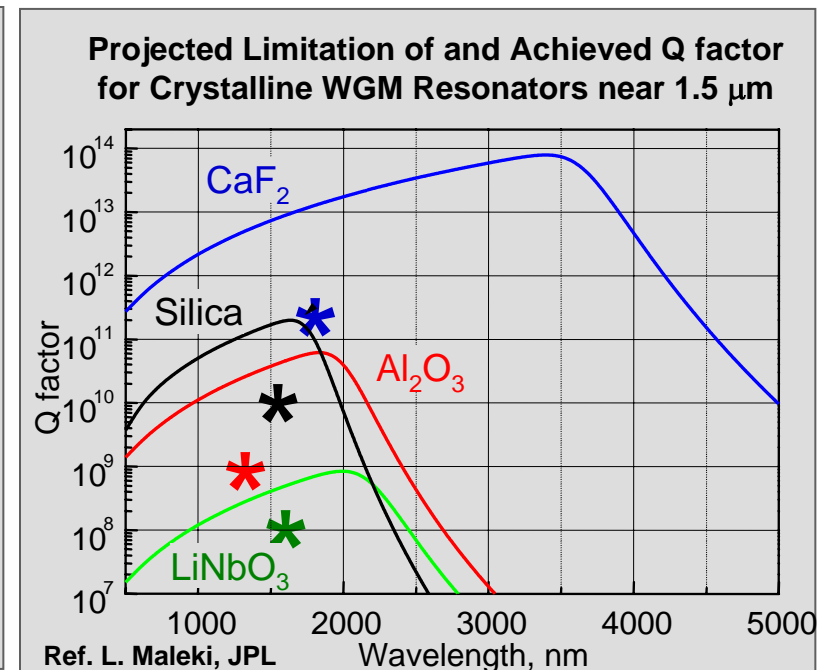
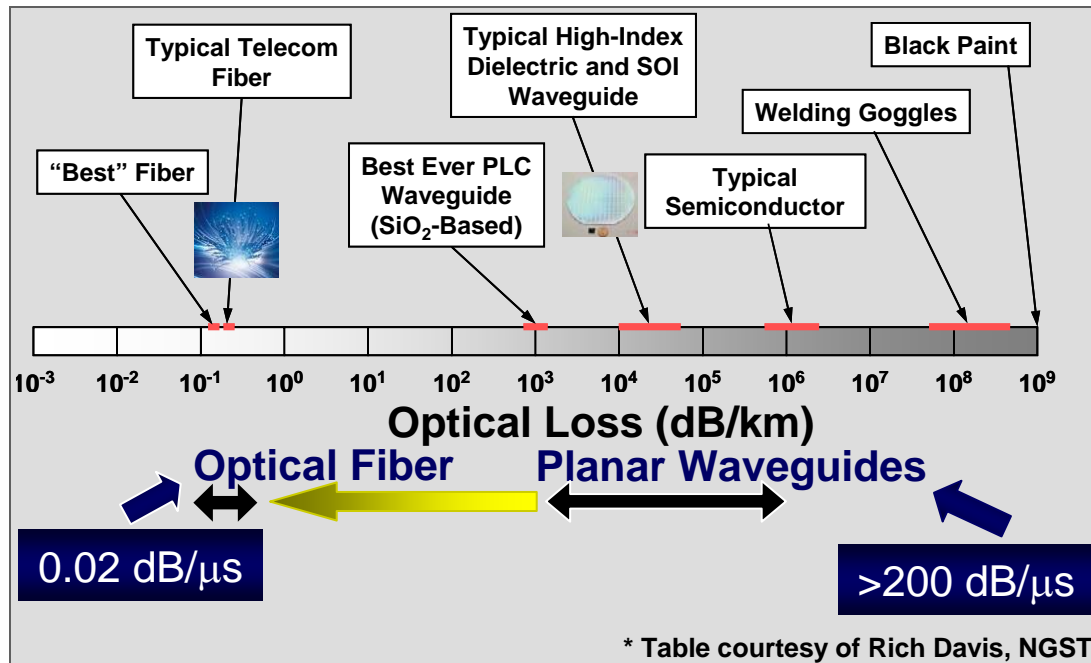


Big Optical Challenge/Opportunity: Hyperfine Optical Filtering Ultra-Low Loss Photonic Waveguides & Resonators



Problems:

- Today's PIC waveguides have losses closer to **Black Paint** than to **Optical Fibers**!
- Today's resonator Q's are well below the predicted limitations



Opportunity:

- Orders of magnitude ($>10^2$) improvement in optical waveguide & resonator loss enables agile RF processing & filtering on a chip (**high resolution I/Q optical processors**)

"Radical Improvements in Chip-Scale Passive Optical Waveguides & Resonators Are Still To Come" -Steve Pappert, 2007

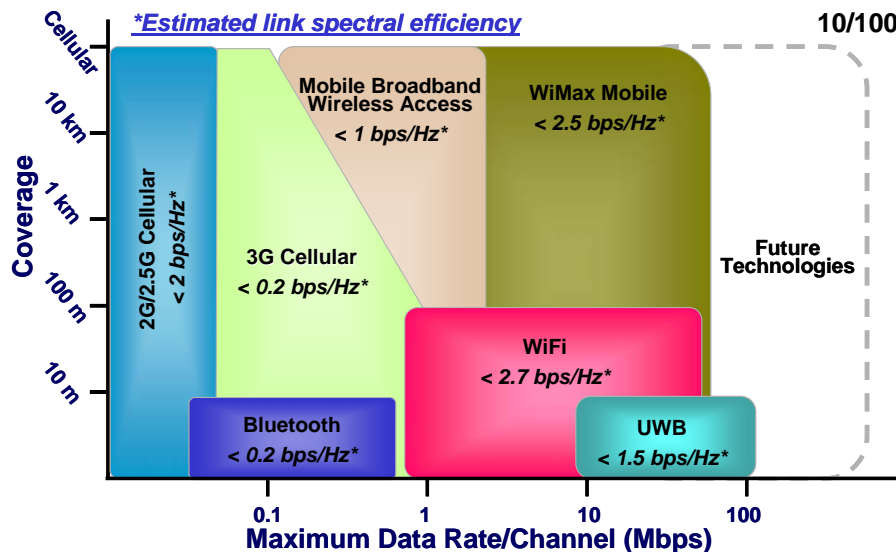
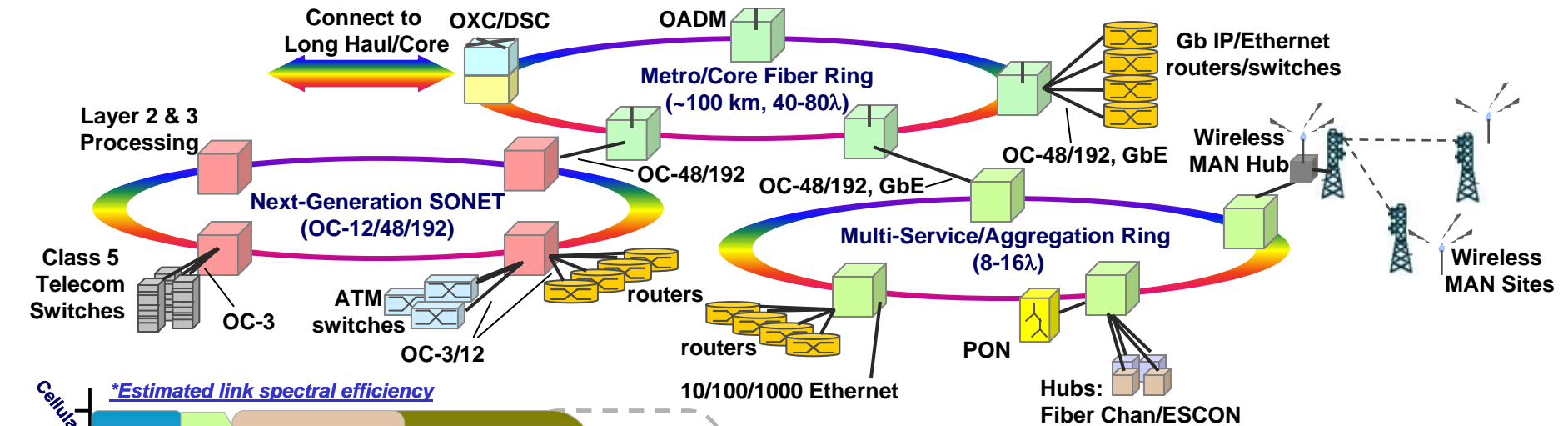


What About Commercial Comms?

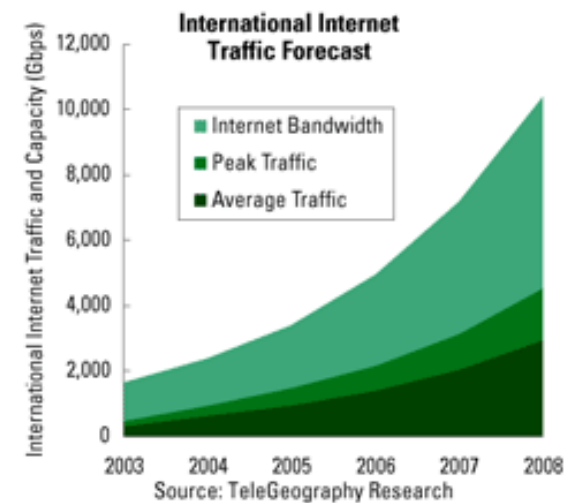
Driven by Capacity (bits/sec/Hz) & Affordability (Mbits/\$)



Telecom/Datacom Network



Ref. A. Azzam, Southeast Wireless, 2004.



Can we affordably bring the bandwidth of the core to the mobile user?

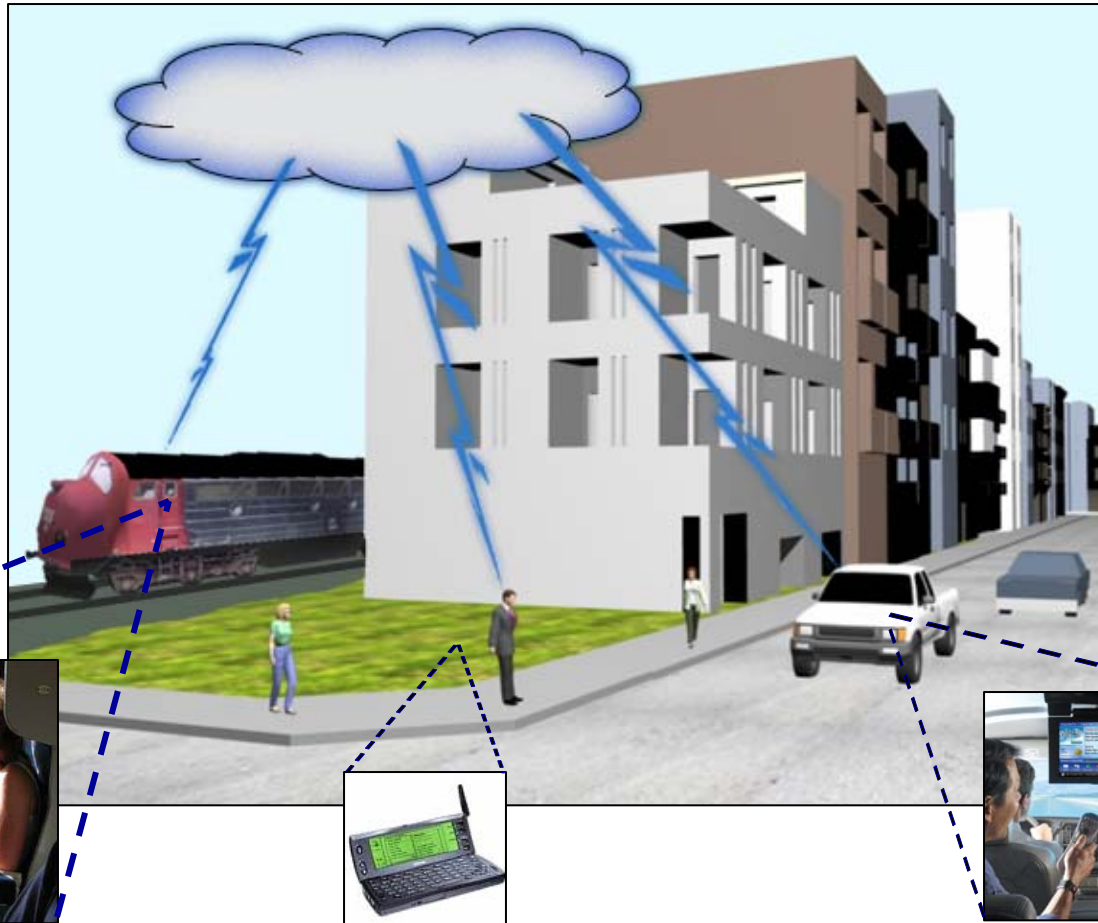


The Commercial Comms Vision

The Mobile Internet



Today's Wired Capacity → Tomorrow Land's Wireless Capacity



Home/Business Impact

24/7
Productivity

Home/Work
Multi-Tasking

Reduced
Operating Costs

Global Virtual
Businesses

The Mobile Internet

Multi-Mbps Voice, Video, Data Services Available Per User On Demand



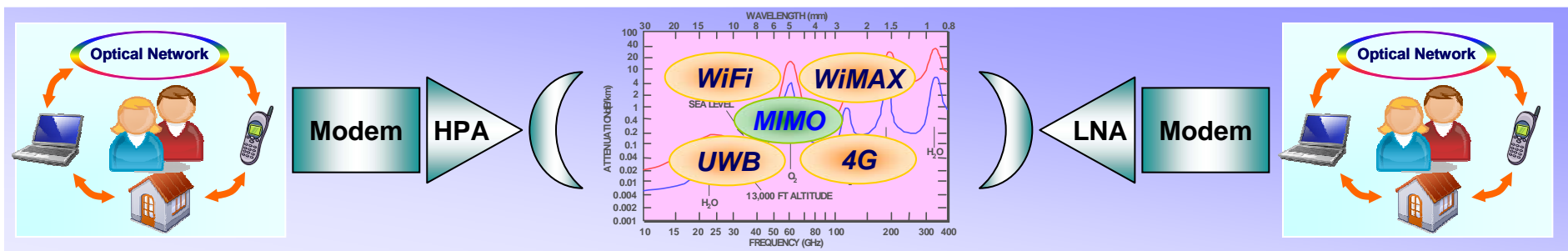
The Mobile Internet

How Do We Get There?

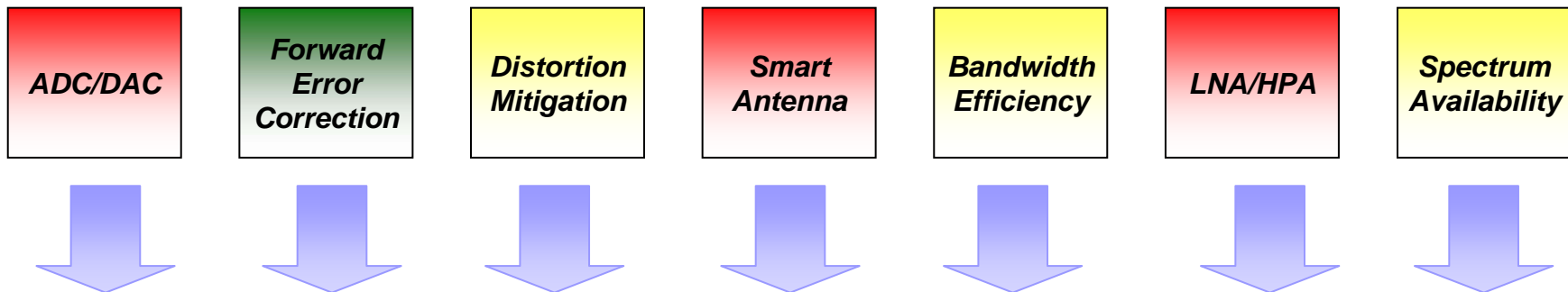


The Last-mile Solution

Novel technologies maximizing the utilization of time, frequency, and spatial domains



Technical Challenges



Bandwidth & Spectral Efficiency → Millions of Available Multi-Mbps Channels



Big Electronic Challenge/Opportunity: Increased Bandwidth & Linearity Power & Low Noise Amplifier, Mixer, ADC/DAC



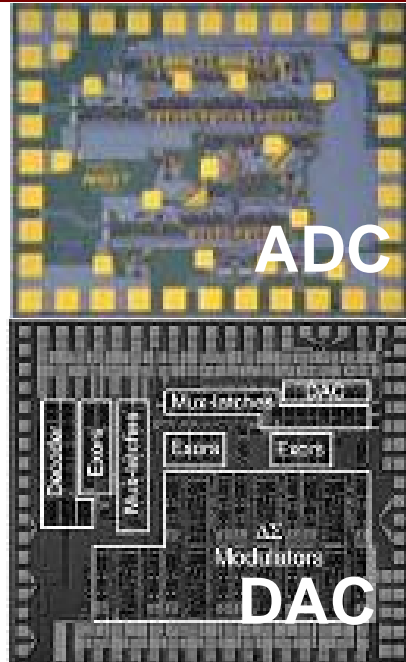
Problems:

- Today's ADCs/DACs have limited bandwidth-resolution product with high power consumption
- Today's Front-End RF electronics have severe linearity limitations

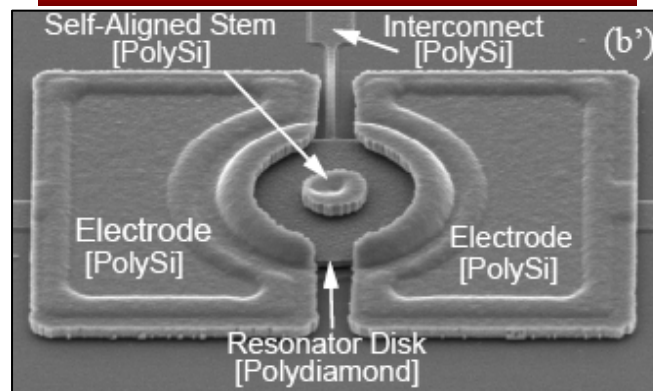
Opportunity:

- Bandgap engineered materials & heterogeneous materials & device integration for optimum RF performance
- Capitalize on remarkable DSP advances to push RF performance beyond material limitations

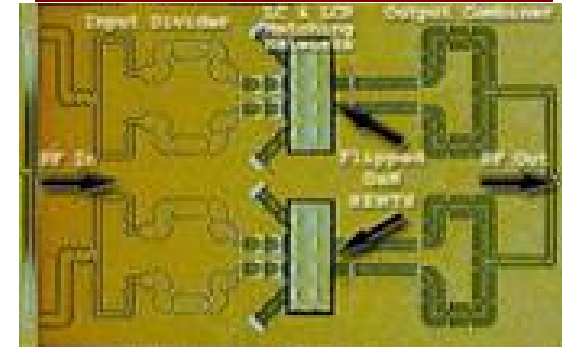
InP Electronic Mixed Signal IC technologies



Narrowband RF Resonators & Filters



GaN MMIC Technologies



Towards THz Transistors



"Dramatic Advances in RF & Mixed Signal Electronics Are Still To Come" -Steve Pappert, 2007

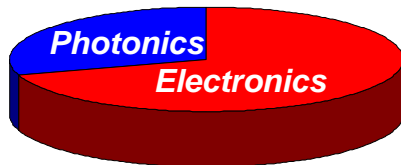


Military & Commercial Mobile Communications

Summary of Key Technology Enablers

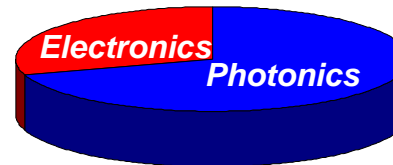


Commercial Comms Enabler Portfolio



- Capacity
- Affordability

Military Comms Enabler Portfolio



- Security/Anti-Jam
- Link Availability

Electronics

- Higher-speed, low power DSP
- Higher-speed mixed signal circuits
- Sub-MMW electronics
- Linear amplifiers & mixers
- Narrow-band fast-tunable RF filters

Photonics

- λ -stable low phase noise optical oscillators
- Optical Phased-Locked-Loops (OPLLs)
- Narrow-band fast-tunable optical filters
- Optical phased arrays
- Opto-Electronic Integration

IF we are successful, revolutionary increases in mobile communication data rates will be available for ...

(1) warfighters and commanders, providing coordinated situational awareness for tactical and strategic superiority.

(2) individuals and businesses, providing coordinated situational awareness for tactical and strategic superiority.

At the end of the day, we are all after the same objective ...

See Anything, From Anywhere, At Anytime; and the mobile internet will take us there using ***Electrons & Photons!***